Pioneer Venus 1978 Multiprobe Spacecraft Simulator

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A test which duplicates the signals of the four probes to be deployed by the PV 78 multiprobe spacecraft has been developed. It will be used for receiver operator training prior to the mission. This article describes the operation and characteristics of the test set.

I. Introduction

The Pioneer Venus 1978 project will consist of two missions: an orbiter and a multiprobe mission. This article deals with the latter. In the multiprobe mission the spacecraft will deploy four probes, each of which will be active for a period of two hours. Only *one* opportunity exists to successfully track the probe signals, and it is necessary therefore that adequate operator training be provided before the mission takes place. To facilitate this training, a multiprobe simulator has been designed to duplicate the signal characteristics of all four probes in their proper deployment sequence. The method of simulating and timing these signals is discussed in this article.

Reference 1 describes the multiprobe mission, its scientific payload, entry sequence and associated telecommunications aspects. Reference 2 describes plans for the configuration of the Deep Space Stations in support of the multiprobe mission.

II. Multiprobe Simulator

The multiprobe simulator provides four S-band test signals, simulating the doppler, modulation and signal level of each of the four probes. Each of the S-band test signals (Fig. 1) consists of an oscillator, modulator and frequency multiplier. A voltage-controlled oscillator is used with the doppler frequency changes being simulated by varying the control voltage to the oscillator. The timings of the various events that occur with each test signal (RF turn-on, doppler, etc.) are controlled by the probe event timer. The turn-on sequence for each test signal is controlled by the probe sequence timer. These functions are discussed in the following paragraphs.

A. Doppler

Figure 2 shows a typical doppler curve of one of the probe signals. It also shows the sequence of events and their times, with reference to RF carrier turn-on, that are expected to take place. The four probe signals will be turned on sequentially at 6-minute intervals, and each will last about 90 minutes.

Telemetry modulation is not applied when the RF carrier is turned on to permit easier acquisition of the signal by receiver operators. After 5 minutes, a timer in the spacecraft turns the modulation on. The carrier decreases in frequency over the next 22 to 24 min as the spacecraft approaches the planet. At an altitude of about 200 km (entry) the probe encounters Venus's dense atmosphere and very rapid deceleration and atmospheric ionization occur, resulting in a temporary loss (blackout) of the spacecraft signals for up to 40 sec after entry. When the signal and modulation return, the probe velocity is decreased and is relatively constant. The doppler shift then becomes relatively constant and the carrier frequency is increased approximately 80 kHz above entry frequency. Impact occurs in approximately 1 hr after entry. Reference 3 describes the method of simulating the doppler profile of the signals from the probes.

B. Timing Sequence

The start of each signal source is controlled by the probe sequence timer. The timer consists of four cascaded BCD counters, driven by the station 1-second time pulse, which provide an elapsed time in seconds. A reset button is provided on the control panel (Fig. 3) to set all timing circuits to zero. The probe sequence timer is started when the large probe modulation signal is applied and detected by a level detector in this timer. The output signals are then applied to the inputs of each probe event timer, in sequence, at the required elapsed time intervals. The event timer output signals are then used in the relay control circuitry to drive the event relays.

Concurrent with the starting of each event timer, the doppler profile generator is activated. The profile generator develops the analog voltage which controls the frequency of the voltage-controlled crystal oscillator (VCXO) to closely duplicate the expected doppler profile of the received signals.

The VCXO output is coupled through a phase modulator which modulates the carrier after an elapsed time of 5 min.

The VCXO frequency is then multiplied to S-band by a ×50 frequency multiplier. A signal combiner is used to combine all four sources linearly and supplies them to the station antenna.

C. Modulation

Four prerecorded modulation signals are supplied to the phase modulators from the Test and Training Subsystem. These provide modulation index and telemetry bit rate changes that occur at predetermined intervals. The phase modulators automatically apply the correct modulation indices and telemetry to each signal.

D. Signal Level

Two S-band attenuators are provided. AT-1 (Fig. 1) is a fixed attenuator that sets the signal level at the antenna input to correspond to the maximum expected signal level to be received from each probe. AT-2 is adjustable to lower the signals to near threshold levels for operator training purposes.

E. Manual Controls

Manual controls are also provided (Fig. 3). Under manual operation, the start of doppler frequency profile, turn-on of the RF signal and modulation can be controlled manually. These events can be started earlier or later than the normal start time that occurs with the sequence timer. This provides the capability of creating an abnormal sequence of events in one of the small probe signals for receiver operator training purposes.

III. Conclusion

A test set for duplicating the signals of the probes from the PV 78 Multiprobe mission has been designed. Lab measurements of a bread board unit verify that the design is adequate to simultaneously simulate the expected signals from all four probes and can be used for DSS receiver operator training, required to assure the successful collection of data from this mission.

References

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3. Johns, C. E., "Pioneer Venus Entry Simulator," in *The Deep Space Network Progress Report 42-33,* pp. 155-158, Jet Propulsion Laboratory, Pasadena, Calif., June 15, 1976.

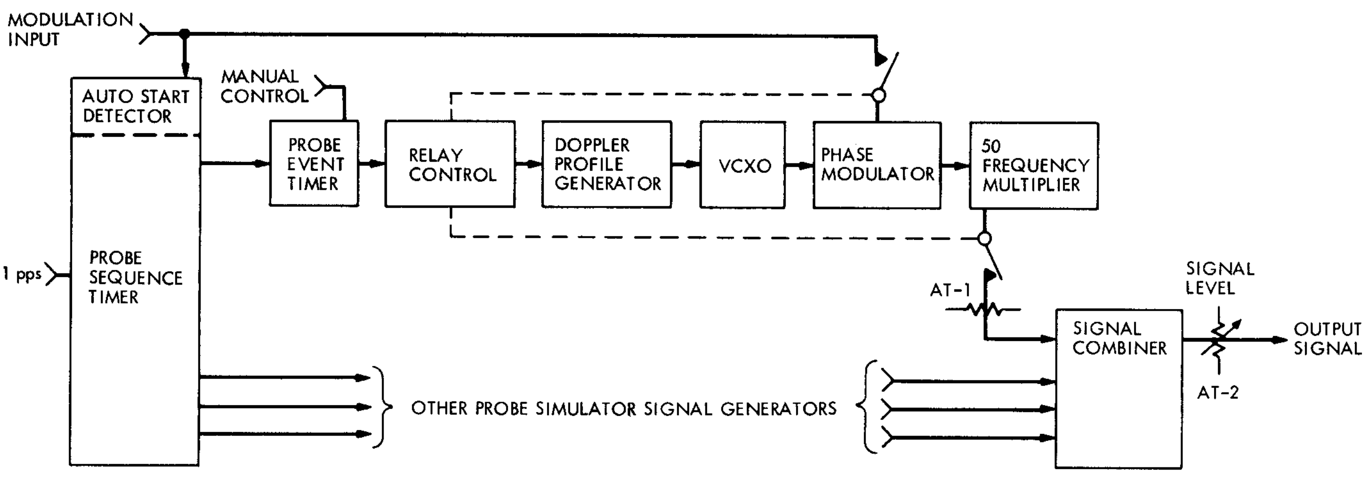

Fig. 1. Block diagram of probe simulator

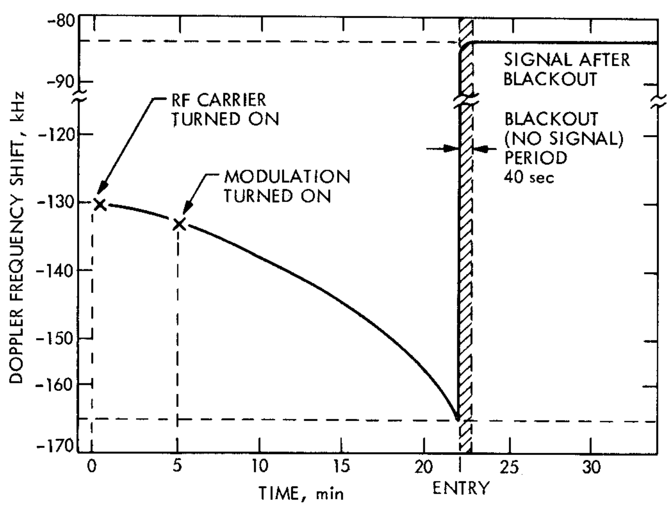

Fig. 2. Typical probe doppler profile

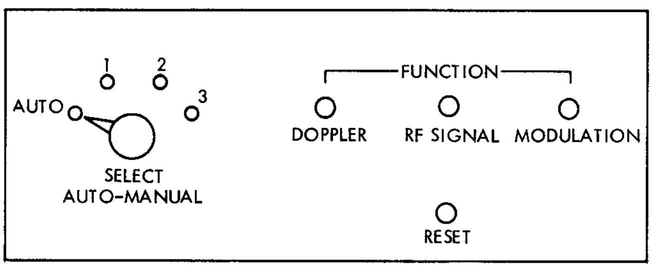

Fig. 3. Manual control panel